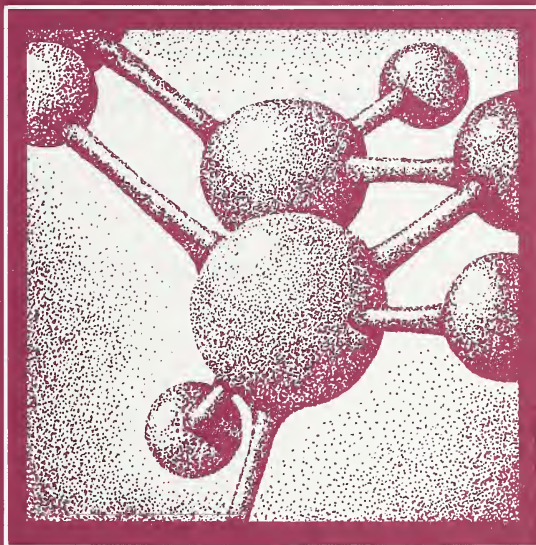


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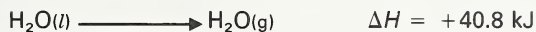
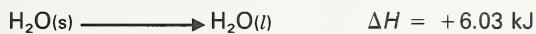
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MISCELLANEOUS



Room temperature = 298 K (25°C)

Standard pressure = 101 kPa

The Avogadro number (N_A) = $6.02 \times 10^{23}/\text{mol}$

Ion product for water (K_w) = $1.00 \times 10^{-14} \text{ mol}^2/\text{L}^2$

Specific heat capacities:

$$\text{H}_2\text{O(s)} = +2.01 \text{ J/(g}^\circ\text{C)}$$

$$\text{H}_2\text{O(l)} = +4.19 \text{ J/(g}^\circ\text{C)}$$

$$\text{H}_2\text{O(g)} = +2.01 \text{ J/(g}^\circ\text{C)}$$

Speed of light (c) = $3.00 \times 10^8 \text{ m/s}$

Charge of 1.00 mol of electrons = $9.65 \times 10^4 \text{ C}$

STANDARD HEATS OF FORMATION

NAME	FORMULA	ΔH_f° (kJ/mol)
aluminum oxide	$\text{Al}_2\text{O}_3(\text{s})$	-1669.8
ammonia	$\text{NH}_3(\text{g})$	-46.2
ammonium chloride	$\text{NH}_4\text{Cl}(\text{s})$	-315.4
ammonium nitrate	$\text{NH}_4\text{NO}_3(\text{s})$	-365.1
barium carbonate	$\text{BaCO}_3(\text{s})$	-1218.8
barium chloride	$\text{BaCl}_2(\text{s})$	-860.1
barium hydroxide	$\text{Ba}(\text{OH})_2(\text{s})$	-946.4
barium oxide	$\text{BaO}(\text{s})$	-558.1
barium sulphate	$\text{BaSO}_4(\text{s})$	-1465.2
benzene	$\text{C}_6\text{H}_6(\text{g})$	+82.9
butane	$\text{C}_4\text{H}_{10}(\text{g})$	-124.7
calcium carbonate	$\text{CaCO}_3(\text{s})$	-1206.9
calcium chloride	$\text{CaCl}_2(\text{s})$	-795.0
calcium hydroxide	$\text{Ca}(\text{OH})_2(\text{s})$	-986.6
calcium oxide	$\text{CaO}(\text{s})$	-635.5
calcium sulphate	$\text{CaSO}_4(\text{s})$	-1432.7
carbon dioxide	$\text{CO}_2(\text{g})$	-393.5
carbon monoxide	$\text{CO}(\text{g})$	-110.5
chromium(III) oxide	$\text{Cr}_2\text{O}_3(\text{s})$	-1128.4
copper(I) oxide	$\text{Cu}_2\text{O}(\text{s})$	-166.7
copper(II) oxide	$\text{CuO}(\text{s})$	-155.2
copper(II) sulphate	$\text{CuSO}_4(\text{s})$	-769.9
copper(II) sulphide	$\text{CuS}(\text{s})$	-48.5
ethane	$\text{C}_2\text{H}_6(\text{g})$	-84.7
ethanoic acid (acetic acid)	$\text{CH}_3\text{COOH}(\text{l})$	-487.0
ethanol	$\text{C}_2\text{H}_5\text{OH}(\text{l})$	-277.6
ethene (ethylene)	$\text{C}_2\text{H}_4(\text{g})$	+52.3
ethyne (acetylene)	$\text{C}_2\text{H}_2(\text{g})$	+226.7
glucose	$\text{C}_6\text{H}_{12}\text{O}_6(\text{s})$	-1273.1
hydrogen bromide	$\text{HBr}(\text{g})$	-36.2
hydrogen chloride	$\text{HCl}(\text{g})$	-92.3
hydrogen fluoride	$\text{HF}(\text{g})$	-286.6
hydrogen iodide	$\text{HI}(\text{g})$	+25.9
hydrogen peroxide	$\text{H}_2\text{O}_2(\text{l})$	-187.6
hydrogen sulphide	$\text{H}_2\text{S}(\text{g})$	-20.1
iron(III) oxide	$\text{Fe}_2\text{O}_3(\text{s})$	-822.2
iron(II, III) oxide (magnetite)	$\text{Fe}_3\text{O}_4(\text{s})$	-1117.1
lead(II) bromide	$\text{PbBr}_2(\text{s})$	-277.0
lead(II) chloride	$\text{PbCl}_2(\text{s})$	-359.2
lead(II) oxide	$\text{PbO}(\text{s})$	-217.9
lead(IV) oxide	$\text{PbO}_2(\text{s})$	-276.6
magnesium carbonate	$\text{MgCO}_3(\text{s})$	-1112.9
magnesium chloride	$\text{MgCl}_2(\text{s})$	-641.8
magnesium hydroxide	$\text{Mg}(\text{OH})_2(\text{s})$	-924.7
magnesium oxide	$\text{MgO}(\text{s})$	-601.8
magnesium sulphate	$\text{MgSO}_4(\text{s})$	-1278.2

STANDARD HEATS OF FORMATION (continued)

NAME	FORMULA	ΔH_f° (kJ/mol)
manganese(II) oxide	MnO(s)	-384.9
manganese(IV) oxide	MnO ₂ (s)	-520.9
mercury(II) oxide	HgO(s)	-90.7
mercury(II) sulphide	HgS(s)	-58.2
methanal (formaldehyde)	CH ₂ O(g)	-115.9
methane	CH ₄ (g)	-74.8
methanoic acid (formic acid)	HCOOH(l)	-409.2
methanol	CH ₃ OH(l)	-238.6
nickel(II) oxide	NiO(s)	-244.3
nitric acid	HNO ₃ (l)	-173.2
nitrogen dioxide	NO ₂ (g)	+33.8
nitrogen monoxide	NO(g)	+90.4
octane	C ₈ H ₁₈ (l)	-208.4
pentane	C ₅ H ₁₂ (l)	-146.4
phosphorus pentachloride	PCl ₅ (g)	-398.9
phosphorus trichloride	PCl ₃ (g)	-306.4
potassium bromide	KBr(s)	-392.2
potassium chlorate	KClO ₃ (s)	-391.2
potassium chloride	KCl(s)	-435.9
potassium hydroxide	KOH(s)	-425.8
propane	C ₃ H ₈ (g)	-103.8
silicon dioxide	SiO ₂ (s)	-859.4
silver bromide	AgBr(s)	-99.5
silver chloride	AgCl(s)	-127.0
silver iodide	AgI(s)	-62.4
sodium bromide	NaBr(s)	-359.9
sodium chloride	NaCl(s)	-411.0
sodium hydroxide	NaOH(s)	-426.7
sodium iodide	NaI(s)	-288.0
sucrose	C ₁₂ H ₂₂ O ₁₁ (s)	-2225.6
sulphur dioxide	SO ₂ (g)	-296.9
sulphuric acid	H ₂ SO ₄ (l)	-811.3
sulphur trioxide	SO ₃ (g)	-395.2
tin(II) chloride	SnCl ₂ (s)	-349.8
tin(IV) chloride	SnCl ₄ (l)	-545.2
tin(II) oxide	SnO(s)	-286.2
tin(IV) oxide	SnO ₂ (s)	-580.7
water (liquid)	H ₂ O(l)	-285.9
water (vapor)	H ₂ O(g)	-241.8
zinc oxide	ZnO(s)	-348.0
zinc sulphide	ZnS(s)	-202.9

NOTES: 1. All heats of formation are measured at 298 K (25°C) and 101 kPa.

2. Molar heats of formation for elements in their naturally occurring form are assumed to be zero.

ACID-BASE INDICATORS AT 298 K (25°C)

INDICATOR	pH RANGE	COLOR CHANGE AS pH INCREASES
methyl violet	0.0 - 1.6	yellow to blue
thymol blue	1.2 - 2.8	red to yellow
	8.0 - 9.6	yellow to blue
orange IV	1.4 - 2.8	red to yellow
methyl orange	3.2 - 4.4	red to yellow
bromocresol green	3.8 - 5.4	yellow to blue
methyl red	4.8 - 6.0	red to yellow
chlorophenol red	5.2 - 6.8	yellow to red
bromothymol blue	6.0 - 7.6	yellow to blue
phenol red	6.6 - 8.0	yellow to red
phenolphthalein	8.2 - 10.0	colorless to pink
thymolphthalein	9.4 - 10.6	colorless to blue
alizarin yellow R	10.1 - 12.0	yellow to red
indigo carmine	11.4 - 13.0	blue to yellow
1, 3, 5-trinitrobenzene	12.0 - 14.0	colorless to orange

RELATIVE STRENGTHS OF ACIDS AND BASES

% REACTION WITH WATER	ACID		CONJUGATE BASE	K_a
	NAME	FORMULA		
100	perchloric acid	$\text{HClO}_4(\text{aq})$	$\text{ClO}_4^-(\text{aq})$	very large
100	hydroiodic acid	$\text{HI}(\text{aq})$	$\text{I}^-(\text{aq})$	very large
100	hydrobromic acid	$\text{HBr}(\text{aq})$	$\text{Br}^-(\text{aq})$	very large
100	hydrochloric acid	$\text{HCl}(\text{aq})$	$\text{Cl}^-(\text{aq})$	very large
100	nitric acid	$\text{HNO}_3(\text{aq})$	$\text{NO}_3^-(\text{aq})$	large
100	sulphuric acid	$\text{H}_2\text{SO}_4(\text{aq})$	$\text{HSO}_4^-(\text{aq})$	large
100	hydronium ion	$\text{H}_3\text{O}^+(\text{aq})$	$\text{H}_2\text{O}(\text{l})$	—
53	oxalic acid	$\text{HOOC}\text{COOH}(\text{aq})$	$\text{HOOC}\text{COO}^-(\text{aq})$	5.9×10^{-2}
32	*sulphurous acid($\text{SO}_2 + \text{H}_2\text{O}$)	$\text{H}_2\text{SO}_3(\text{aq})$	$\text{HSO}_3^-(\text{aq})$	1.5×10^{-2}
29	hydrogen sulphate ion	$\text{HSO}_4^-(\text{aq})$	$\text{SO}_4^{2-}(\text{aq})$	1.2×10^{-2}
24	phosphoric acid	$\text{H}_3\text{PO}_4(\text{aq})$	$\text{H}_2\text{PO}_4^-(\text{aq})$	7.5×10^{-3}
6.8	**nitrous acid	$\text{HNO}_2(\text{aq})$	$\text{NO}_2^-(\text{aq})$	4.6×10^{-4}
5.9	hydrofluoric acid	$\text{HF}(\text{aq})$	$\text{F}^-(\text{aq})$	3.5×10^{-4}
4.2	methanoic acid	$\text{HCOOH}(\text{aq})$	$\text{HCOO}^-(\text{aq})$	1.8×10^{-4}
—	methyl orange	$\text{HMO}(\text{aq})$	$\text{MO}^-(\text{aq})$	$\sim 10^{-4}$
2.5	benzoic acid	$\text{C}_6\text{H}_5\text{COOH}(\text{aq})$	$\text{C}_6\text{H}_5\text{COO}^-(\text{aq})$	6.5×10^{-5}
2.5	hydrogen oxalate ion	$\text{HOOC}\text{COO}^-(\text{aq})$	$\text{OOC}\text{COO}^{2-}(\text{aq})$	6.4×10^{-5}
1.3	ethanoic (acetic) acid	$\text{CH}_3\text{COOH}(\text{aq})$	$\text{CH}_3\text{COO}^-(\text{aq})$	1.8×10^{-5}
0.21	carbonic acid($\text{CO}_2 + \text{H}_2\text{O}$)	$\text{H}_2\text{CO}_3(\text{aq})$	$\text{HCO}_3^-(\text{aq})$	4.3×10^{-7}
—	bromothymol blue	$\text{HBb}(\text{aq})$	$\text{Bb}^-(\text{aq})$	$\sim 10^{-7}$
0.10	*hydrogen sulphite ion	$\text{HSO}_3^-(\text{aq})$	$\text{SO}_3^{2-}(\text{aq})$	1.0×10^{-7}
9.5×10^{-2}	hydrosulphuric acid	$\text{H}_2\text{S}(\text{aq})$	$\text{HS}^-(\text{aq})$	9.1×10^{-8}
7.9×10^{-2}	dihydrogen phosphate ion	$\text{H}_2\text{PO}_4^-(\text{aq})$	$\text{HPO}_4^{2-}(\text{aq})$	6.2×10^{-8}
5.4×10^{-2}	*hypochlorous acid	$\text{HOCl}(\text{aq})$	$\text{OCl}^-(\text{aq})$	3.0×10^{-8}
—	phenolphthalein	$\text{HPh}(\text{aq})$	$\text{Ph}^-(\text{aq})$	$\sim 10^{-9}$
8.5×10^{-3}	boric acid	$\text{H}_3\text{BO}_3(\text{aq})$	$\text{H}_2\text{BO}_3^-(\text{aq})$	7.3×10^{-10}
7.5×10^{-3}	ammonium ion	$\text{NH}_4^+(\text{aq})$	$\text{NH}_3(\text{aq})$	5.6×10^{-10}
7.0×10^{-3}	hydrocyanic acid	$\text{HCN}(\text{aq})$	$\text{CN}^-(\text{aq})$	4.9×10^{-10}
2.4×10^{-3}	hydrogen carbonate ion	$\text{HCO}_3^-(\text{aq})$	$\text{CO}_3^{2-}(\text{aq})$	5.6×10^{-11}
3.3×10^{-4}	hydrogen sulphide ion	$\text{HS}^-(\text{aq})$	$\text{S}^{2-}(\text{aq})$	1.1×10^{-12}
1.5×10^{-4}	*hydrogen phosphate ion	$\text{HPO}_4^{2-}(\text{aq})$	$\text{PO}_4^{3-}(\text{aq})$	2.2×10^{-13}
1.8×10^{-7}	water (55.5 mol/L)	$\text{H}_2\text{O}(\text{l})$	$\text{OH}^-(\text{aq})$	1.0×10^{-14}
0	hydroxide ion	$\text{OH}^-(\text{aq})$	$\text{O}^{2-}(\text{aq})$	very small

NOTE: Unless otherwise indicated, all measurements are made at 298 K (25°C) with acid concentrations of 0.10 mol/L (except for indicators, which are not normally used at that high a concentration).

* Temperature = 291 K (18°C)

** Temperature = 285.5 K (12.5°C)

PERIODIC CHART OF THE ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIIB	IB	IIB	IIIA	IVA	V	VIA	VIIA	VIIIA or O																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
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11 Na 22.99 sodium	12 Mg 24.31 magnesium																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.90 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.71 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.74 gallium	32 Ge 72.59 germanium	33 As 74.92 arsenic	34 Se 78.96 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton	37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.94 molybdenum	43 Tc 98.91 technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.40 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.69 tin	51 Sb 121.75 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.30 xenon	55 Cs 132.91 cesium	56 Ba 137.33 barium	57-71 La 138.91 lanthanum	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.85 tungsten	75 Re 186.21 rhenium	76 Os 190.20 osmium	77 Ir 192.22 iridium	78 Pt 195.09 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.37 thallium	82 Pb 207.19 lead	83 Bi 208.98 bismuth	84 Po (209) polonium	85 At (210) astatine	86 Rn (222) radon	87 Fr (223) francium	88 Ra 226.03 radium	89-103 Ac 227.04 actinium	104 Rf (260) rutherfordium	105 Ha (260) hahnium	106 (263) (263)	107 (263) (263)	108 (263) (263)	109 (263) (263)	110 (263) (263)	111 (263) (263)	112 (263) (263)	113 (263) (263)	114 (263) (263)	115 (263) (263)	116 (263) (263)	117 (263) (263)	118 (263) (263)	119 (263) (263)	120 (263) (263)	121 (263) (263)	122 (263) (263)	123 (263) (263)	124 (263) (263)	125 (263) (263)	126 (263) (263)	127 (263) (263)	128 (263) (263)	129 (263) (263)	130 (263) (263)	131 (263) (263)	132 (263) (263)	133 (263) (263)	134 (263) (263)	135 (263) (263)	136 (263) (263)	137 (263) (263)	138 (263) (263)	139 (263) (263)	140 (263) (263)	141 (263) (263)	142 (263) (263)	143 (263) (263)	144 (263) (263)	145 (263) (263)	146 (263) (263)	147 (263) (263)	148 (263) (263)	149 (263) (263)	150 (263) (263)	151 (263) (263)	152 (263) (263)	153 (263) 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(263)	216 (263) (263)	217 (263) (263)	218 (263) (263)	219 (263) (263)	220 (263) (263)	221 (263) (263)	222 (263) (263)	223 (263) (263)	224 (263) (263)	225 (263) (263)	226 (263) (263)	227 (263) (263)	228 (263) (263)	229 (263) (263)	230 (263) (263)	231 (263) (263)	232 (263) (263)	233 (263) (263)	234 (263) (263)	235 (263) (263)	236 (263) (263)	237 (263) (263)	238 (263) (263)	239 (263) (263)	240 (263) (263)	241 (263) (263)	242 (263) (263)	243 (263) (263)	244 (263) (263)	245 (263) (263)	246 (263) (263)	247 (263) (263)	248 (263) (263)	249 (263) (263)	250 (263) (263)	251 (263) (263)	252 (263) (263)	253 (263) (263)	254 (263) (263)	255 (263) (263)	256 (263) (263)	257 (263) (263)	258 (263) (263)	259 (263) (263)	260 (263) (263)	261 (263) (263)	262 (263) (263)	263 (263) (263)	264 (263) (263)	265 (263) (263)	266 (263) (263)	267 (263) (263)	268 (263) (263)	269 (263) (263)	270 (263) (263)	271 (263) (263)	272 (263) (263)	273 (263) (263)	274 (263) (263)	275 (263) (263)	276 (263) (263)	277 (263) (263)	278 (263) (263)	279 (263) (263)	280 (263) (263)	281 (263) (263)	282 (263) (263)	283 (263) (263)	284 (263) (263)	285 (263) (263)	286 (263) (263)	287 (263) (263)	288 (263) (263)	289 (263) (263)	290 (263) (263)	291 (263) (263)	292 (263) (263)	293 (263) (263)	294 (263) (263)	295 (263) (263)	296 (263) (263)	297 (263) (263)	298 (263) (263)	299 (263) (263)	300 (263) (263)	301 (263) (263)	302 (263) (263)	303 (263) (263)	304 (263) (263)	305 (263) (263)	306 (263) (263)	307 (263) (263)	308 (263) (263)	309 (263) (263)	310 (263) (263)	311 (263) (263)	312 (263) (263)	313 (263) (263)	314 (263) (263)	315 (263) (263)	316 (263) (263)	317 (263) (263)	318 (263) (263)	319 (263) (263)	320 (263) (263)	321 (263) (263)	322 (263) (263)	323 (263) (263)	324 (263) (263)	325 (263) (263)	326 (263) (263)	327 (263) (263)	328 (263) (263)	329 (263) (263)	330 (263) (263)	331 (263) (263)	332 (263) (263)	333 (263) (263)	334 (263) (263)	335 (263) (263)	336 (263) (263)	337 (263) (263)	338 (263) (263)	339 (263) (263)	340 (263) (263)	341 (263) (263)	342 (263) (263)	343 (263) (263)	344 (263) (263)	345 (263) (263)	346 (263) (263)	347 (263) (263)	348 (263) (263)	349 (263) (263)	350 (263) (263)	351 (263) (263)	352 (263) (263)	353 (263) (263)	354 (263) (263)	355 (263) (263)	356 (263) (263)	357 (263) (263)	358 (263) (263)	359 (263) (263)	360 (263) (263)	361 (263) (263)	362 (263) (263)	363 (263) (263)	364 (263) (263)	365 (263) (263)	366 (263) (263)	367 (263) (263)	368 (263) (263)	369 (263) (263)	370 (263) (263)	371 (263) (263)	372 (263) (263)	373 (263) (263)	374 (263) (263)	375 (263) (263)	376 (263) (263)	377 (263) (263)	378 (263) (263)	379 (263) (263)	380 (263) (263)	381 (263) (263)	382 (263) (263)	383 (263) (263)	384 (263) (263)	385 (263) (263)	386 (263) (263)	387 (263) (263)	388 (263) (263)	389 (263) (263)	390 (263) (263)	391 (263) (263)	392 (263) (263)	393 (263) (263)	394 (263) (263)	395 (263) (263)	396 (263) (263)	397 (263) (263)	398 (263) (263)	399 (263) (263)	400 (263) (263)	401 (263) (263)	402 (263) (263)	403 (263) (263)	404 (263) (263)	405 (263) (263)	406 (263) (263)	407 (263) (263)	408 (263) (263)	409 (263) (263)	410 (263) (263)	411 (263) (263)	412 (263) (263)	413 (263) (263)	414 (263) (263)	415 (263) (263)	416 (263) (263)	417 (263) (263)	418 (263) (263)	419 (263) (263)	420 (263) (263)	421 (263) (263)	422 (263) (263)	423 (263) (263)	424 (263) (263)	425 (263) (263)	426 (263) (263)	427 (263) (263)	428 (263) (263)	429 (263) (263)	430 (263) (263)	431 (263) (263)	432 (263) (263)	433 (263) (263)	434 (263) (263)	435 (263) (263)	436 (263) (263)	437 (263) (263)	438 (263) (263)	439 (263) (263)	440 (263) (263)	441 (263) (263)	442 (263) (263)	443 (263) (263)	444 (263) (263)	445 (263) (263)	446 (263) (263)	447 (263) (263)	448 (263) (263)	449 (263) (263)	450 (263) (263)	451 (263) (263)	452 (263) (263)	453 (263) (263)	454 (263) (263)	455 (263) (263)	456 (263) (263)	457 (263) (263)	458 (263) (263)	459 (263) (263)	460 (263) (263)	461 (263) (263)	462 (263) (263)	463 (263) (263)	464 (263) (263)	465 (263) (263)	466 (263) (263)	467 (263) (263)	468 (263) (263)	469 (263) (263)	470 (263) (263)	471 (263) (263)	472 (263) (263)	473 (263) (263)	474 (263) (263)	475 (263) (263)	476 (263) (263)	477 (263) (263)	478 (263) (263)	479 (263) (263)	480 (263) (263)	481 (263) (263)	482 (263) (263)	483 (263) (263)	484 (263) (263)	485 (263) (263)	486 (263) (263)	487 (263) (263)	488 (263) (263)	489 (263) (263)	490 (263) (263)	491 (263) (263)	492 (263) (263)	493 (263) (263)	494 (263) (263)	495 (263) (263)	496 (263) (263)	497 (263) (263)	498 (263) (263)	499 (263) (263)	500 (263) (263)	501 (263) (263)	502 (263) (263)	503 (263) (263)	504 (263) (263)	505 (263) (263)	506 (263) (263)	507 (263) (263)	508 (263) (263)	509 (263) (263)	510 (263) (263)	511 (263) (263)	512 (263) (263)	513 (263) (263)	514 (263) (263)	515 (263) (263)	516 (263) (263)	517 (263) (263)	518 (263) (263)	519 (263) (263)	520 (263) (263)	521 (263) (263)	522 (263) (263)	523 (263) (263)	524 (263) (263)	525 (263) (263)	526 (263) (263)	527 (263) (263)	528 (263) (263)	529 (263) (263)	530 (263) (263)	531 (263) (263)	532 (263) (263)	533 (263) (263)	534 (263) (263)	535 (263) (263)	536 (263) (263)	537 (263) (263)	538 (263) (263)	539 (263) (263)	540 (263) (263)	541 (263) (263)	542 (263) (263)	543 (263) (263)	544 (263) (263)	545 (263) (263)	546 (263) (263)	547 (263) (263)	548 (263) (263)	549 (263) (263)	550 (263) (263)	551 (263) (263)	552 (263) (263)	553 (263) (263)	554 (263) (263)	555 (263) (263)	556 (263) (263)	557 (263) (263)	558 (263) (263)	559 (263) (263)	560 (263) (263)	561 (263) (263)	562 (263) (263)	563 (263) (263)	564 (263) (263)	565 (263) (263)	566 (263) (263)	567 (263) (263)	568 (263) (263)	569 (263) (263)	570 (263) (263)	571 (263) (263)	572 (263) (263)	573 (263) (263)	574 (263) (263)	575 (263) (263)	576 (263) (263)	577 (263) (263)	578 (263) (263)	579 (263) (263)	580 (263) (263)	581 (263) (263)	582 (263) (263)	583 (263) (263)	584 (263) (263)	585 (263) (263)	586 (263) (263)	587 (263) (263)	588 (263) (263)	589 (263) (263)	590 (263) (263)	591 (263) (263)	592 (263) (263)	593 (263) (263)	594 (263) (263)	595 (263) (263)	596 (263) (263)	597 (263) (263)	598 (263) (263)	599 (263) (263)	600 (263) (263)	601 (263) (263)	602 (263) (263)	603 (263) (263)	604 (263) (263)	605 (263) (263)	606 (263) (263)	607 (263) (263)	608 (263) (263)	609 (263) (263)	610 (263)<

PERIODIC TABLE OF IONS

GROUP
IA

1	H ⁺ hydrogen
3	Li ⁺ lithium
11	Na ⁺ sodium

IIA

4	Be ²⁺ beryllium
12	Mg ²⁺ magnesium

TABLE OF COMPLEX IONS

acetate CH ₃ COO ⁻	perchlorate ClO ₄ ⁻	oxalate O ²⁻	hydrogen sulphate HSO ₄ ⁻
ammonium NH ₄ ⁺	chlorite ClO ₂ ⁻	permanganate MnO ₄ ⁻	bisulphate HSO ₄ ⁻
benzoate C ₆ H ₅ COO ⁻	hypochlorite ClO ⁻ or OCl ⁻	phosphate PO ₄ ³⁻	hydrogen sulphite HSO ₃ ⁻
borate BO ₃ ³⁻	chromate CrO ₄ ²⁻	hydrogen phosphate HPO ₄ ²⁻	bisulphite HSO ₃ ⁻
bromate BrO ₃ ⁻	dichromate Cr ₂ O ₇ ²⁻	thiocyanate SCN ⁻	thiosulphate S ₂ O ₃ ²⁻
carbonate CO ₃ ²⁻	cyanide CN ⁻	silicate SiO ₃ ²⁻	
hydrogen carbonate HCO ₃ ⁻	hydroxide OH ⁻	sulphate SO ₄ ²⁻	
bicarbonate ClO ₃ ⁻	iodate IO ₃ ⁻	sulphite SO ₃ ²⁻	
chlorate ClO ₃ ⁻	nitrate NO ₃ ⁻	hydrogen sulphide HS ⁻	
	nitrite NO ₂ ⁻	bisulphide	

VIIA

1	H ⁺ hydride
9	F ⁻ fluoride
17	Cl ⁻ chloride

VIA

8	O ²⁻ oxide
16	S ²⁻ sulphide

VA

7	N ³⁻ nitride
15	P ³⁻ phosphide

IVA

6	C carbon
14	Si silicon

IIIA

5	B boron
13	Al ³⁺ aluminum

IIA

3	Li ⁺ lithium
11	Na ⁺ sodium
19	K ⁺ potassium
37	Rb ⁺ rubidium
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81	Tl ³⁺ thallium(I)
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32	Ge ⁴⁺ germanium
50	Sn ⁴⁺ stannous
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7	N ³⁻ nitride
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33	As ³⁻ arsenide
51	Sb ³⁻ antimony(III)
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IIA

8	O ²⁻ oxide
16	S ²⁻ sulphide
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52	Te ²⁻ telluride
84	Po ²⁻ polonium(IV)

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9	F ⁻ fluoride
17	Cl ⁻ chloride
35	Br ⁻ bromide
53	I ⁻ iodide
85	At ⁻ astatide

IIA

10	Ne neon
18	Ar argon
36	Kr krypton
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32	Ge ⁴⁺ germanium
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82	Pb ⁴⁺ plumbous

IIA

7	N ³⁻ nitride
15	P

TWO PLACE LOGS

NO.	LOG	NO.	LOG	NO.	LOG	NO.	LOG	NO.	LOG
1.0	0.00	3.0	0.48	5.0	0.70	7.0	0.85	9.0	0.95
1.1	0.04	3.1	0.49	5.1	0.71	7.1	0.85	9.1	0.96
1.2	0.08	3.2	0.51	5.2	0.72	7.2	0.86	9.2	0.96
1.3	0.11	3.3	0.52	5.3	0.72	7.3	0.86	9.3	0.97
1.4	0.15	3.4	0.53	5.4	0.73	7.4	0.87	9.4	0.97
1.5	0.18	3.5	0.54	5.5	0.74	7.5	0.88	9.5	0.98
1.6	0.20	3.6	0.56	5.6	0.75	7.6	0.88	9.6	0.98
1.7	0.23	3.7	0.57	5.7	0.76	7.7	0.89	9.7	0.99
1.8	0.26	3.8	0.58	5.8	0.76	7.8	0.89	9.8	0.99
1.9	0.28	3.9	0.59	5.9	0.77	7.9	0.90	9.9	1.00
2.0	0.30	4.0	0.60	6.0	0.78	8.0	0.90	1.00	0.00
2.1	0.32	4.1	0.61	6.1	0.79	8.1	0.91	1.01	0.00
2.2	0.34	4.2	0.62	6.2	0.79	8.2	0.91	1.02	0.01
2.3	0.36	4.3	0.63	6.3	0.80	8.3	0.92	1.03	0.01
2.4	0.38	4.4	0.64	6.4	0.81	8.4	0.92	1.04	0.02
2.5	0.40	4.5	0.65	6.5	0.81	8.5	0.93	1.05	0.02
2.6	0.41	4.6	0.66	6.6	0.82	8.6	0.93	1.06	0.03
2.7	0.43	4.7	0.67	6.7	0.83	8.7	0.94	1.07	0.03
2.8	0.45	4.8	0.68	6.8	0.83	8.8	0.94	1.08	0.03
2.9	0.46	4.9	0.69	6.9	0.84	8.9	0.95	1.09	0.04

STANDARD ELECTRODE POTENTIALS

	Reduction Half-Reaction	E° (V)	
	$\text{F}_2(\text{g}) + 2\text{e}^- \longrightarrow 2\text{F}^-(\text{aq})$	+ 2.87	
	$\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\text{l})$	+ 1.68	
	$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \longrightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}(\text{l})$	+ 1.49	
	$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Au}(\text{s})$	+ 1.42	
	$\text{Cl}_2(\text{g}) + 2\text{e}^- \longrightarrow 2\text{Cl}^-(\text{aq})$	+ 1.36	
	$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \longrightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$	+ 1.33	
	$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \longrightarrow 2\text{H}_2\text{O}(\text{l})$	+ 1.23	
	$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{Mn}^{2+}(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$	+ 1.21	
	$\text{Br}_2(\text{l}) + 2\text{e}^- \longrightarrow 2\text{Br}^-(\text{aq})$	+ 1.07	
	$\text{AuCl}_4^-(\text{aq}) + 3\text{e}^- \longrightarrow \text{Au}(\text{s}) + 4\text{Cl}^-(\text{aq})$	+ 0.99	
	$\text{NO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + 3\text{e}^- \longrightarrow \text{NO}(\text{g}) + 2\text{H}_2\text{O}(\text{l})$	+ 0.96	
	$2\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Hg}_2^{2+}(\text{aq})$	+ 0.91	
	$\text{Hg}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Hg}(\text{l})$	+ 0.85	
	$\frac{1}{2}\text{O}_2(\text{g}) + 2\text{H}^+(\text{aq})(1.0 \times 10^{-7} \frac{\text{mol}}{\text{L}}) + 2\text{e}^- \longrightarrow \text{H}_2\text{O}(\text{l})$	+ 0.82	
	$\text{NO}_3^-(\text{aq}) + 2\text{H}^+(\text{aq}) + \text{e}^- \longrightarrow \text{NO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$	+ 0.81	
	$\text{Ag}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Ag}(\text{s})$	+ 0.80	
	$\text{Hg}_2^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow 2\text{Hg}(\text{l})$	+ 0.80	
	$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Fe}^{2+}(\text{aq})$	+ 0.77	
	$\text{I}_2(\text{s}) + 2\text{e}^- \longrightarrow 2\text{I}^-(\text{aq})$	+ 0.54	
	$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \longrightarrow 4\text{OH}^-(\text{aq})$	+ 0.40	
	$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Cu}(\text{s})$	+ 0.34	
	$\text{SO}_4^{2-}(\text{aq}) + 4\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2\text{SO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$	+ 0.20	
	$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Sn}^{2+}(\text{aq})$	+ 0.15	
	$\frac{1}{8}\text{S}_8(\text{s}) + 2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2\text{S}(\text{aq})$	+ 0.14	
	$\text{AgBr}(\text{s}) + \text{e}^- \longrightarrow \text{Ag}(\text{s}) + \text{Br}^-(\text{aq})$	+ 0.07	
	$2\text{H}^+(\text{aq}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g})$	0.00	
	$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Fe}(\text{s})$	- 0.04	
	$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Pb}(\text{s})$	- 0.13	
	$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Sn}(\text{s})$	- 0.14	
	$\text{AgI}(\text{s}) + \text{e}^- \longrightarrow \text{Ag}(\text{s}) + \text{I}^-(\text{aq})$	- 0.15	
	$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ni}(\text{s})$	- 0.23	
	$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Co}(\text{s})$	- 0.28	
	$\text{PbSO}_4(\text{s}) + 2\text{e}^- \longrightarrow \text{Pb}(\text{s}) + \text{SO}_4^{2-}(\text{aq})$	- 0.36	
	$\text{Cd}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Cd}(\text{s})$	- 0.40	
	$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Fe}(\text{s})$	- 0.41	
	$\text{Cr}^{3+}(\text{aq}) + \text{e}^- \longrightarrow \text{Cr}^{2+}(\text{aq})$	- 0.41	
	$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow 2\text{OH}^-(\text{aq})(1 \times 10^{-7} \frac{\text{mol}}{\text{L}}) + \text{H}_2(\text{g})$	- 0.42	
	$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Cr}(\text{s})$	- 0.74	
	$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Zn}(\text{s})$	- 0.76	
	$2\text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	- 0.83	
	$\text{SO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) + 2\text{e}^- \longrightarrow \text{SO}_3^{2-}(\text{aq}) + 2\text{OH}^-(\text{aq})$	- 0.92	
	$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \longrightarrow \text{Al}(\text{s})$	- 1.66	
	$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Mg}(\text{s})$	- 2.38	
	$\text{Na}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Na}(\text{s})$	- 2.71	
	$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ca}(\text{s})$	- 2.76	
	$\text{Ba}^{2+}(\text{aq}) + 2\text{e}^- \longrightarrow \text{Ba}(\text{s})$	- 2.90	
	$\text{K}^+(\text{aq}) + \text{e}^- \longrightarrow \text{K}(\text{s})$	- 2.92	
	$\text{Li}^+(\text{aq}) + \text{e}^- \longrightarrow \text{Li}(\text{s})$	- 3.05	

Note: Unless otherwise indicated

- all ions in this table are in aqueous solution
- all concentrations are 1.0 mol/L and all gases are at 101 kPa pressure
- E° values have been measured at 298 K (25°C)

SOLUBILITY OF SOME IONIC COMPOUNDS IN WATER AT 298 K (25°C)

ION	Group IA		NH ₄ ⁺	NO ₃ ⁻	CH ₃ COO ⁻	Cl ⁻	SO ₄ ²⁻	S ²⁻	OH ⁻	PO ₄ ³⁻
	alkali metal ions	H ⁺ (H ₃ O ⁺)				Br ⁻ I ⁻				SO ₃ ²⁻ CO ₃ ²⁻
SOLUBILITY OF >0.1 mol/L (VERY SOLUBLE)	All	All	All	All	Most	Most	Most	Group IA	Group IA	Group IA
								Group IIA	NH ₄ ⁺	NH ₄ ⁺
								NH ₄ ⁺	Sr ²⁺	
								Ba ²⁺		
								Tl ⁺		
SOLUBILITY OF <0.1 mol/L (SLIGHTLY SOLUBLE)	None	None	None	None	Ag ⁺	Ag ⁺	Ca ²⁺	Most	Most	Most
						Pb ²⁺	Sr ²⁺			
						Hg ₂ ²⁺	Ba ²⁺			
						Cu ⁺	Ra ²⁺			
							Ag ⁺			
						Tl ⁺	Pb ²⁺			

N.L.C. - B.N.C.



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